A SINGLE PAIR OF SAFETY GEAR DOWN/UP OPERATING

Gerhard Schlosser, Aufzugtechnologie Dachau, Germany

ABSTRACT:

According to the regulation of the European communities it will be necessary to provide all lifts with a safety feature to prevent free fall and uncontrolled up movements in case of components or power failures. The description following states that we only use a single pair of safety gear, activated by a standard overspeed governor. The design of the safety gear allows the full safe stop in both directions. Our system can cope with different load conditions created in down respectively in up direction.

INTRODUCTION:

ALL SAFE, GENTLEMEN, ALL SAFE!

Elisha G. Otis demonstrated the safe elevator in the New York Crystal Palace in 1854 every evening, thus starting the automatic vertical transport of passengers.

Up to this time, elevators had been installed without automatic safety gears. And if yet a safety gear was built in, it had to be operated by the passengers. This was of course not terribly safe in the free fall!

You will recognize the ratchets of the guide rails and the plate springs releasing the safety gear in case of broken ropes and meshing the stopper cams in. The subsequent stop was very abrupt.

The blocking mechanism of intermeshing parts was used for a long time and is still allowed for low-speed elevators. With instantaneous safeties, however, safety gears nowadays at least provide stopping distances of some centimeters. An elevator expert known to me personally always had "resilient legs" when using an elevator, as in 1936 he had suffered from a pelvic fracture due to an emergency stop.

Shortly after the invention of the safety gear, elevator manufacturers proceeded to have the safety gear released by a centrifugal governor, which means that the safety gear was released as soon as the car run at excess speed.

Lift speed always increased and consequently safety gears had to be designed to stop the lift cars down gradually. For this purpose smooth guide rails were required to which the braking force could be applied evenly. In Germany, this kind of rails was put on the market in about 1925, known as Mannstaedt profiles.

Nowadays, vertical transport is safeguarded so perfectly, that elevators are regarded as the safest means of transport. In an advertising brochure of 1975, it can be read that using an elevator is by five times safer than walking up- or downstairs. To this have contributed the safety gears a great deal from the very beginning up today.

Of course, modern vertical transport systems nowadays are provided with a large variety of safety devices also at the doors, in the lift well and in the control circuits, which are regarded as equally inevitable as the device that prevents the free fall. It is interesting that already on a former IAEE the opinion had been expressed that lift cars provided with safety gears were out, as they could be substituted for example by a safe design. Even our esteemed colleague, Dr. Gerhard Schiffner, said in this lecture given in Rome in 1990, that the extreme case of the free fall of a car due to broken ropes does for example in Germany virtually no longer occur nowadays under normal lift operating conditions. It is not necessary to repeat the opinions of Mr. Strakosch and Mr. Nederbragt.

The author is a joint proprietor of two companies in Germany and Austria, who manufacture no complete lifts but lift components of modern lift car slings, such as

progressive safety gears
roller guides
load weighing systems

Regarding progressive safety gears, I suppose that you as lift manufacturers have already heard from or observed total drops of lift cars, which thanks to the foreseen effect of the safety gear went off without injury to the passengers.

We have supplied more than 45.000 safety gears up to now and were reported four total drops after completion of commissioning:

* The bearing rope- plate came loose from the isolating buffers in the overhead cross-beam, as it had not sufficiently been secured against detaching.
* A rope- pulley stuck in its bearing and blocked; the automatic running monitor failed as the car stopped. The ropes got so hot that they tore.
* The driving shaft broke.
* The kingpin of the counterweight had not sufficiently been secured and came loose on one side. Particularly at the counterweight, securing is often neglected although possible damages are the same as with the lift car.

During installation of the lift, total drops occur again and again. For instance:

* At an indirect hydraulic lift a pipe screwing came loose.
* The chain of the mounting crane broke.
* The loaded car started slipping as the counterweight was being unloaded.

New safety regulations:

It would go beyond the scope of this lecture to interprete the new safety regulations in Europe, becoming valid in July 1997 on a voluntary basis and binding as from July 1999 on. In fact, safety gears shall not only be effective for down-travels including the possible total drop, but also shall safety gears be effective for up-travels of empty lift cars. As per a statistical inquiry in Germany, this feature is rather necessary! Moreover, uncontrolled travels play an important role in these new statutes. In any case, harmonised uniform safety regulations will be applicable to lifts manufactured in the European Community. One of the decisive items thereof, the upward effect of the safety gear, will be subject of this lecture.

Down operation:

Up to total loads of 5.000 kg and travel speeds of up to 3 m/sec we apply progressive safety gears of the eccentric type, the brake springs of which are compressed by the chuck up to a pre-defined position. The chuck (EC) is a knurled gripping eccentric. The casing (5) that embraces the guide rail is a welded construction floating on a kingpin. On one side is arranged the counterpart (4) taking up the spring (7) power by the passive brake jaw (6) from the arbour to the chuck (EC) + bearing eccentric (LE) + active gripping jaw (2). Chuck + bearing eccentrics on both sides are made as a unit. The chuck and the active gripping jaw meets at the engagement point. These preset meeting positions tighten up the disc spring columns up to the kinetic limited spring stroke.

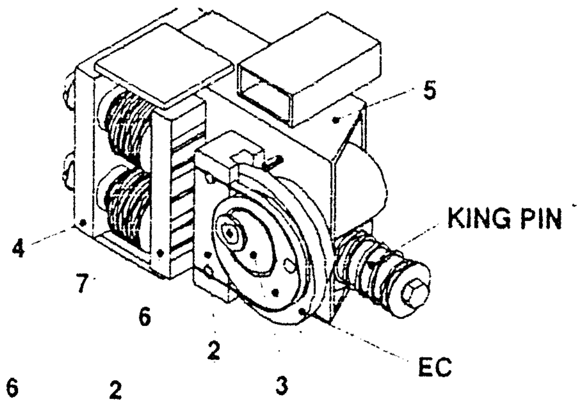


Fig. - 1

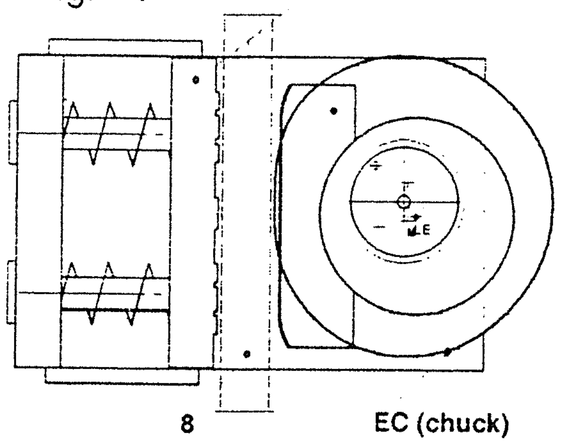


Fig. 1
Inoperative position = idle position. Neither the active gripping jaw (2) nor the passive gripping jaw (6) nor the chuck (EC) touch the guide rail (8).

DOWN OPERATION

Fig. - 2

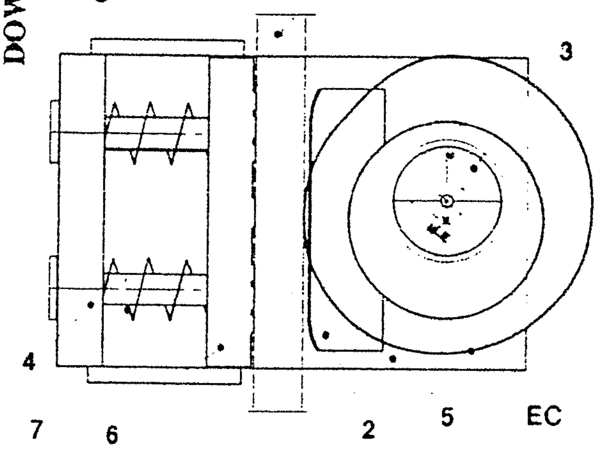


Fig. 2
Gripping.
The chuck is turned by the speed governor until the knurled eccentric surface of the chuck and the active and passive brake jaws touch the guide rail (8) on both sides.
As from this moment, the chuck starts compressing the pressure springs (7).
The casing (5) moves towards the passive brake jaw (6).The arbour of the eccentrics (3) takes up the clamp forces with regard to the counterpart (4).

Fig. - 3

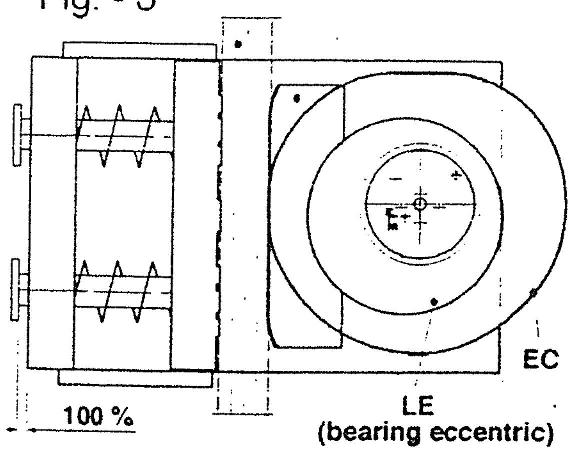


Fig. 3
Stop position.
The bearing eccentrics (LE) make the active gripping jaw (2) touch the guide rail (8). By that the chuck itself is released with the effect that the position of the chuck (EC) cannot be changed anymore. Thus the car is progressively stopped down. Dead center position of the bearing eccentrics (LE) is reached just before the stop position of the safety gear (M_{LE}).

This gripping system has very well proven in 35.000 pairs of safety gears up to now. It is to be pointed to the fact that in Germany, first official safety gear tests are executed by loading the lift car with 1.5 times the rated load and applying the rated speed. For this purpose, the overspeed governor is engaged, the safety gear switch and the overspeed governor switch are bridged and the brake of the traction machine manually held open. Conclusions are drawn from the stopping distance. Other safety gear tests is applied the rated load only, which means that these tests are done in the same way as in many other countries: the brake of the traction machine is manually held open waiting until the overspeed governor is engaged, in order to draw conclusions from the stopping distance with respect to a free fall. Regular follow-up tests are done with empty lift cars by simulating the deceleration, for example the system ADIAS of the TÜV Bayern-Sachsen (Technical Surveyance Authority in the German Federal States of Bayern and Sachsen) . Similar tests are also done in other countries or regular free fall tests by the lift manufacturers in their own factories.
The system of the bearing eccentric cams running behind the advance chuck is an elegant solution! Eccentrics are nothing else than wound-up oblique planes.

By our system it is not complicated to generate clamped forces to catch the lift car in down-direction. The active gripping jaw runs behund the bearing eccentric cams and catches up with the chuck in the stopping position. Of course, there are different parameters to be considered:

a) In case of self-locking, the safety gear easily engages but does not disengage.

b) If the running- behind angle between the chuck and the eccentric bearing cams is chosen too wide, the active gripping jaw retracts after having reached the stop position. This makes, however,the chuck intervene to have the active gripping jaw gearing again, and so on.

Two different eccentrics on a mutual eccentric radius - this was empirically solved in the seventies. The number of parameters to be considered had been clear.

Down- and up-operation

a) The down-operating safety gear shall catch the dropping lift car. Tests are executed in compliance with the relevant safety regulations.

b) The up-operating safety gear shall stop a lift car, which is either empty or occupied by one passenger only. The testing procedure is still not well defined.

What are the solutions suggested by the European safety standards?

1) Safety gears installeds at the lift car.
   This solution is most probably the simplest one and is also developed by us. By our system of the gripping jaw borne by an eccentric cam running behind the chuck, a solution is provided for down- and up-movements. Only one overspeed governor is required, complete with rope, tensioning weight, releasing linkage and safety switch.
   To meet different weight conditions, the safety gear can be rated for a deceleation of 0.6g for down-movements (rated load + dead weight) and a deceleration of 0.3g for up-movements (rated load/2) by varying the spring layers or by using different chucks.
2) Safety gears for the counterweight
   - each safety gear comes along with an overspeed governor plus rope and tensioning weight as well as releasing linkage and safety switch. This means that an extra power lead is required.
   - What about accessible space under the counterweight? This situation asks for a safety gear!
3) Rope Brakes
   - These devices require their own power supply.
   - If these devices are operated actively, they need controllers.
4) Traction sheave brake
   - In many cases impossible due to restricted space.
   - This is a costly solution.

Remarks to the first solution:
The diameter of the bearing eccentric shall be kept, on which the active gripping jaw lies. the pressure springs are compressed by the chuck. The chuck is now formed as a multiple-contour-cam.

UP- OPERATION

Fig. - 1

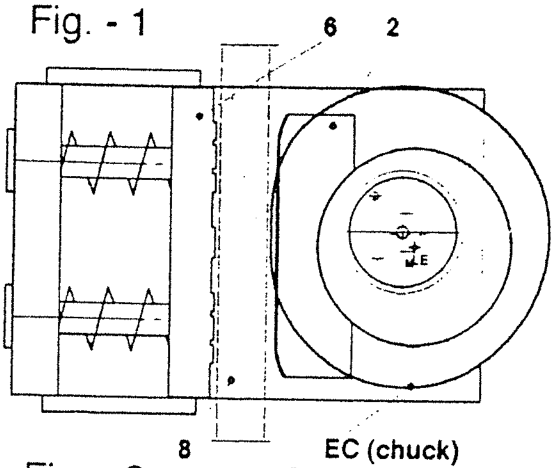


Fig. 1
Inoperative position = idle position.
Neither the active gripping jaw (2) nor the passive gripping jaw (6) nor the chuck (EC) touch the guide rail(8).

Fig. - 2

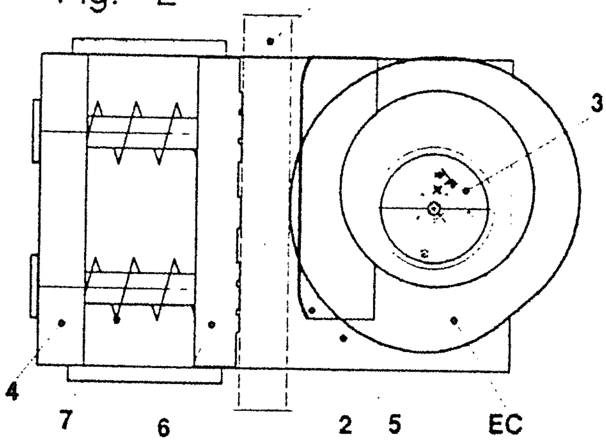


Fig. 2
Gripping.
The chuck (EC) is turned by the overspeed governor until the knurled surface of the chuck (EC) and the passive gripping jaw (6) touch to the guide rail (8) on both sides. As from this moment, the chuck (EC) starts tensioning the pressure springs (7). The casing (5) moves towards the passive gripping jaw (6). The arbour of the clamp forces with regard to the counterpart (4).

Fig. - 3

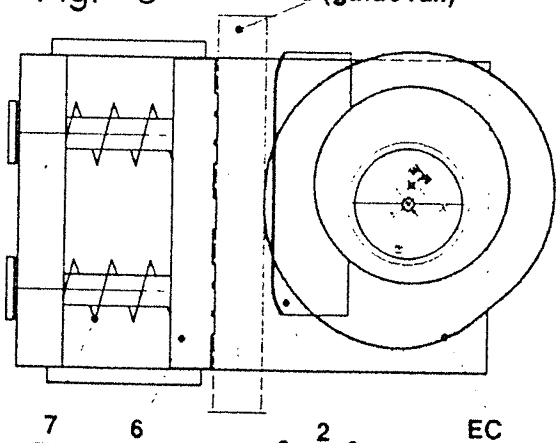


Fig. 3
Deceleration.
The chuck (EC) is slightly pressed to the guide rail (8). Consequently, the passive gripping jaw (6) tensions the pressure springs (7), in order to overcome the long rotatory distance and initiate a safe and gentle stopping.

Fig. - 4

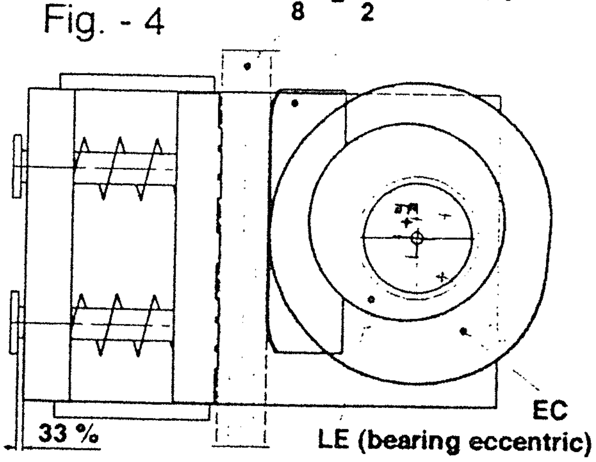


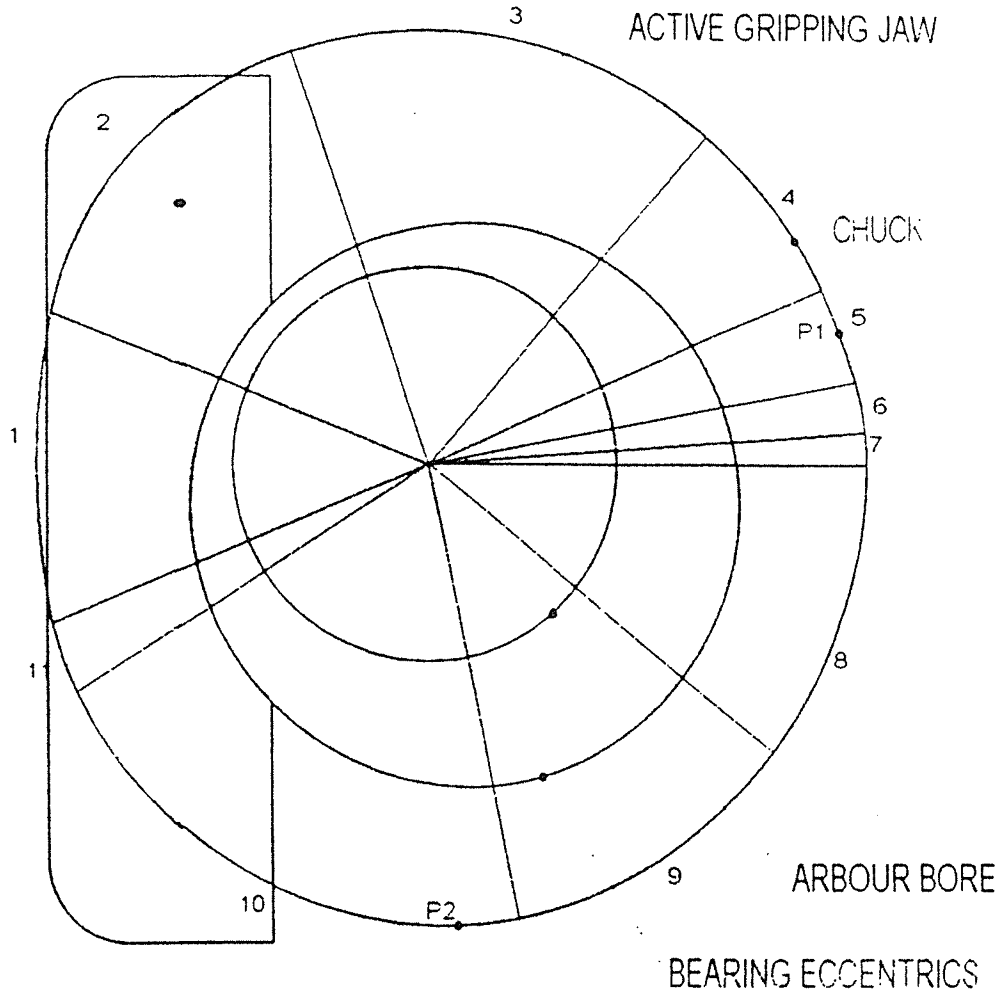
Fig. 4
Stop position.
The bearing eccentrics (LE) make the active gripping jaw (2) touch to the guide rail (8). By that the chuck (EC) itself is released with the effect that the position of the chuck (EC) cannot be changed anymore. Thus the car is progressively stopped down. The dead center position (MLE) of the bearing eccentrics (LE) is reached just before the safety gear enters in the stop position.

Description of the chuck:

CHUCK
Amidst active gripping jaw

BEARING ECCENTRICS
On both sides of chuck

ACTIVE GRIPPING JAW
Slotted amidst for the chuck set on bearing eccentrics



Description of the chuck:

Section 1: Idle position = inoperative position.
Designed to be very flat in order to get in contact with the rail at a small angle and to have - on the other hand - the necessary free space for the inoperative possition.

Section 10: This section corresponds to the contour of the original, proven chuck for down-operating safety gears.P2 is the vanishing point for down-operation.

Section 2: Smooth transition from section 1 to section 3, without any butt.

Section 3: A circle with its center in the center of the arbour bore, of the system. This section evenly approaches to section 5.

Section 4: Smooth transition from section 3 to section 5, without any butt.

Section 5: In correspondence to section 10 for down-operation, section 5 serves for the up-operation of the safety gear. At the position of vanishing point P1, the plate springs are compressed by 33%, whereas at the position of vanishing point P2, they are compressed by 100%.
In the same way corresponds the differential slope of P1 to the one of P2.

Section 6, 7,8 and 9: These sections of the chuck never touch to the rail and serve to have a multiple-circle-contour of the chuck that can easily be knurled without any butts.

Considering that eccentrics are wound-up oblique planes, this system is very elegant, really fine. In comparison with wedges, eccentrics offer the advantage of being borne by an arbour, which takes up forces regardless of their effective direction. By simply varying the position of the disks of different contours to each other, the gripping position of the active gripping jaw can be adjusted.

Those are the determining factors:

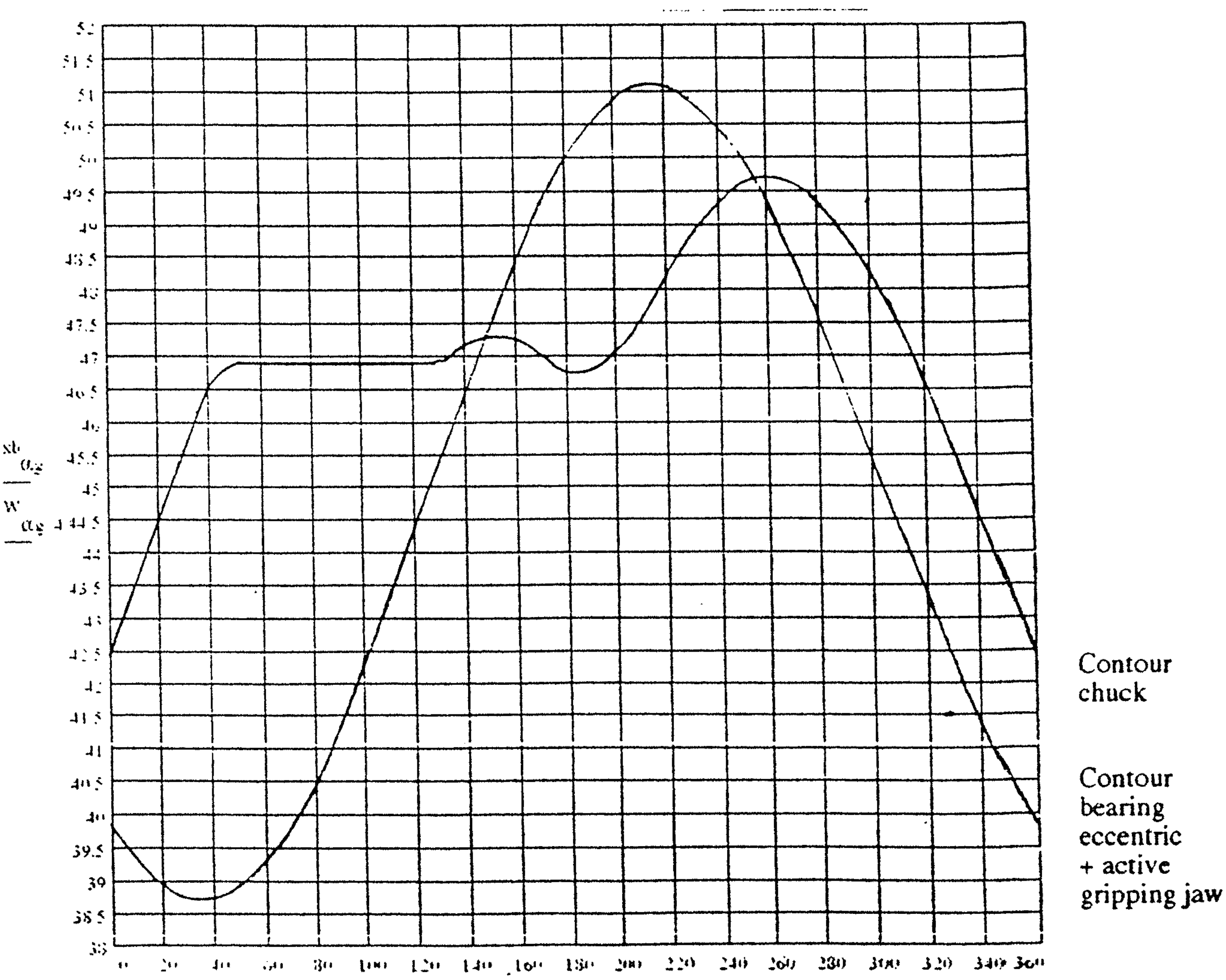
a) In the case of self-locking, the active gripping jaw easily engages but does not disengage.

b) If the running-behind angle between the chuck and the eccentric bearing cams is chosen too wide, this will make the safety gear coming loose steadily.

c) Nowadays, however, by means of a modern machining center, the contours are easily generated and the discs knurled in one operating cycle. And this is done in the same time as it took a metal working lathe of the seventies to knurl eccentrics.

d) The most elegant solutions are found by designing the cams by a PC:

- First are determined the vanishing points.
- The vanishing point for down-operation results from the two-eccentrics-principle (knurled gripping eccentric/bearing eccentric cams/active gripping jaw), which has successfully been applied since 25 years.
- The vanishing point for up-operation is defined by the reduced spring distance:
  100 % down-operation
  33 % up- operation.
  At the same time the proven differential slope of the down-operation is also applied to the contour, which concerns the up-operation.



UP-OPERATION ——→ ←—— DOWN-OPERATION

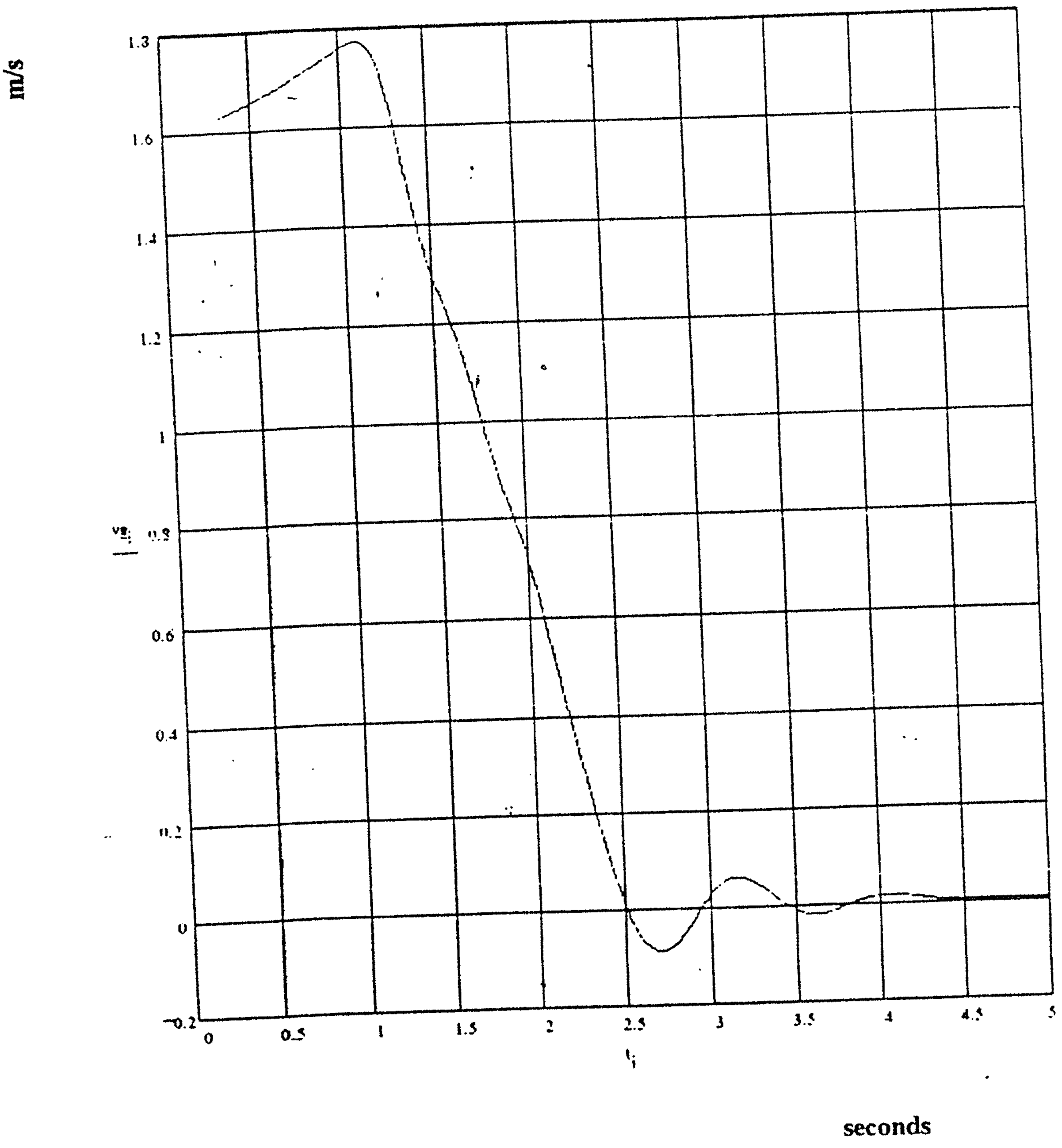
A great number of tests have been made at our test elevator in Amaliendorf. The main advatage of this elevator is that the guide rails are separated from the catch rails - very easy to replace after a couple of tests!

The elevator has been adjusted to following data:

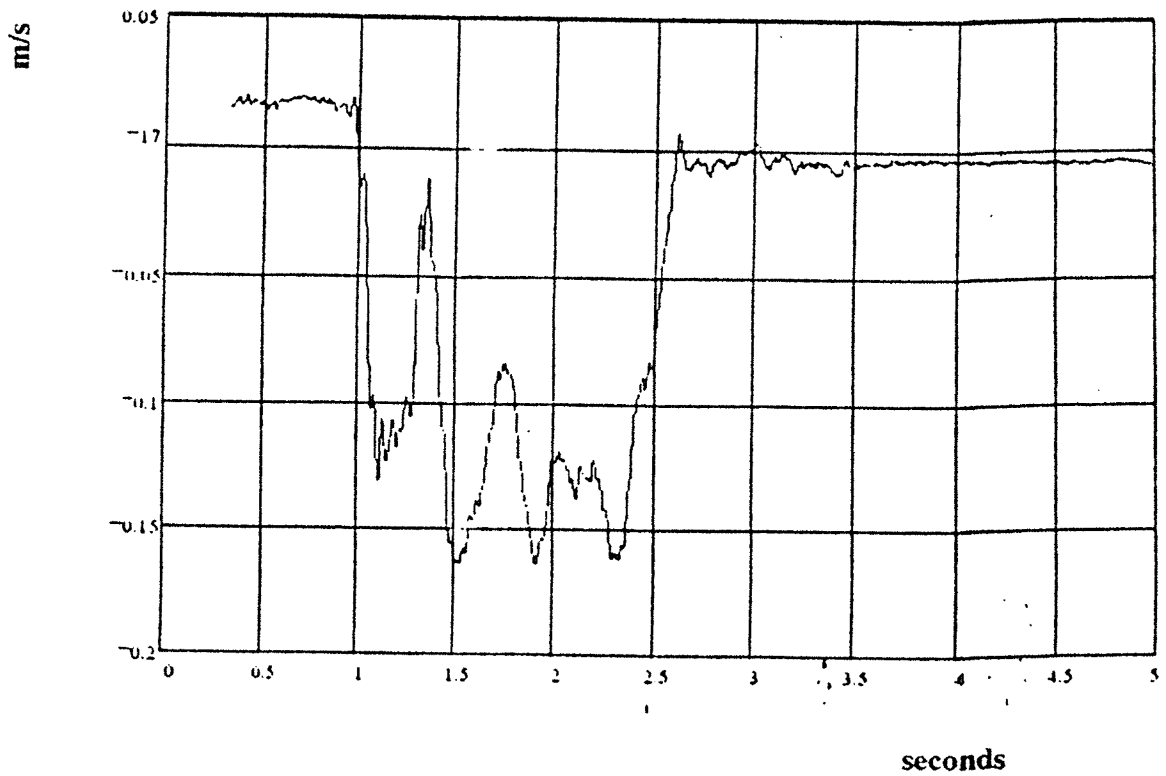
carweight	1100 kg roped 1 :1
counterweight	2900 kg roped 2 :1
payload	350 kg
traction sheave	Ø 600 mm , 4 ropes Ø 13 mm
roller guides	Vulkollan (backpack elevator)
planetary drive	ratio 1 : 37,7

Until now we made from the beginning 7 different chucks, numbering from 27.11 to 27.71.
Following are for an example the graphs of chuck Nr. 27.61 which seems to be the best until now.
The test has been made with the empty car in UP-OPERATION.

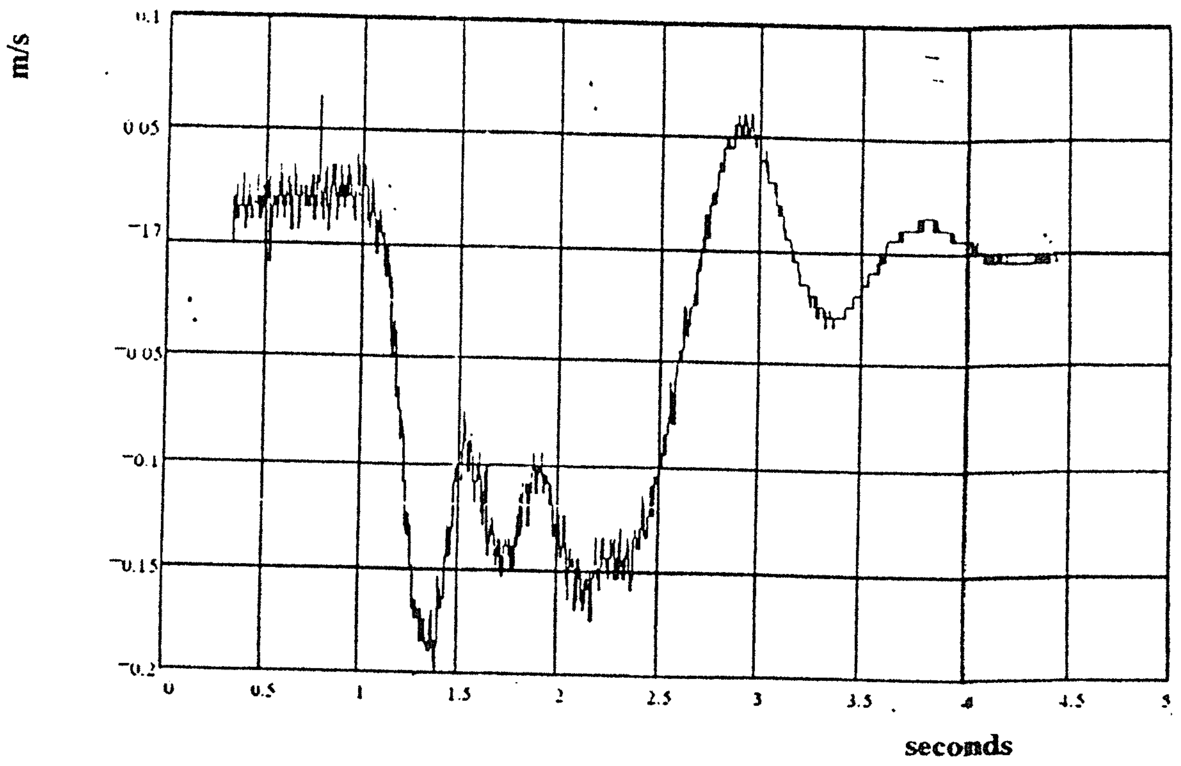
VELOCITY:



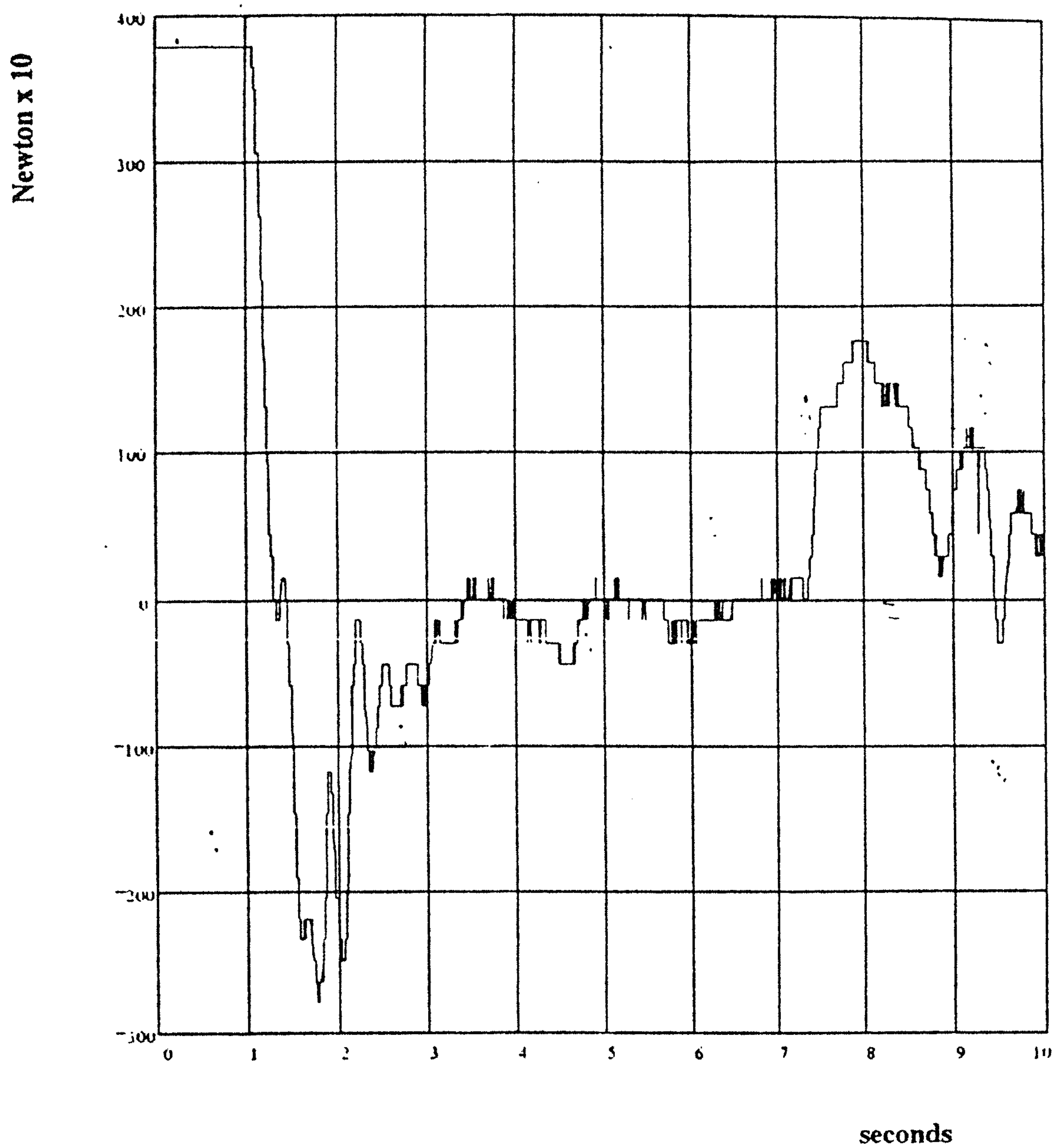
DECELERATION:
Direct measurement



DECELERATION:
Numeriacal calculated by velocity



PULL OUT FORCE
Direct measurement



Those are the decisive advantages offered by our system:

a) The spring characteristic can be adjusted according to the given mass, guide shoes, travel speed, features of the traction sheave, gear ratio, kinetic energy of the gear and efficiency of the gear.

b) If the spring characteristic cannot be imitated accordingly, the cam disc can be shaped at choice.

Biographical notes:

Gerhard A. Schlosser, Masch.-Ing.HTL has been working on the mechanical side of elevator design since 1955. As managing director he look over full responsibility for two companies manufacturing specialized elevator components in 1977.